Dissecting a rare triple galaxy merger - radio and mm-observations toward the Bird

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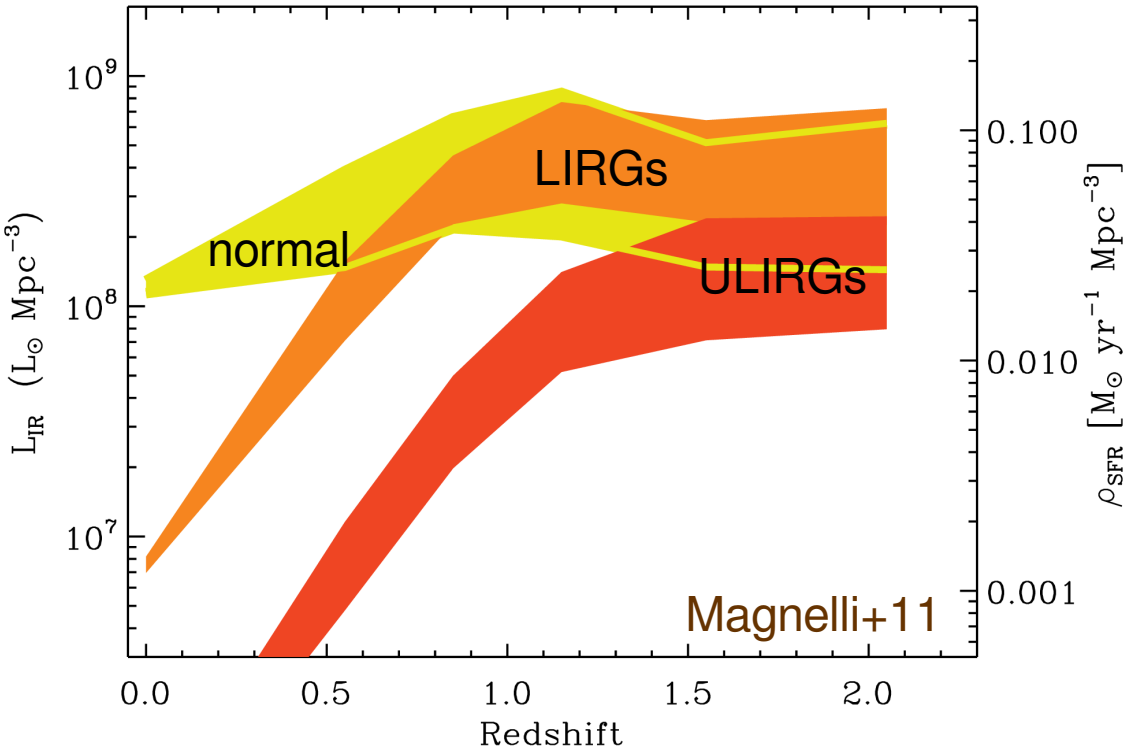
Luminous Infrared Galaxies

$10^{11} \leq L_{FIR}(L_\odot) < 10^{12}$

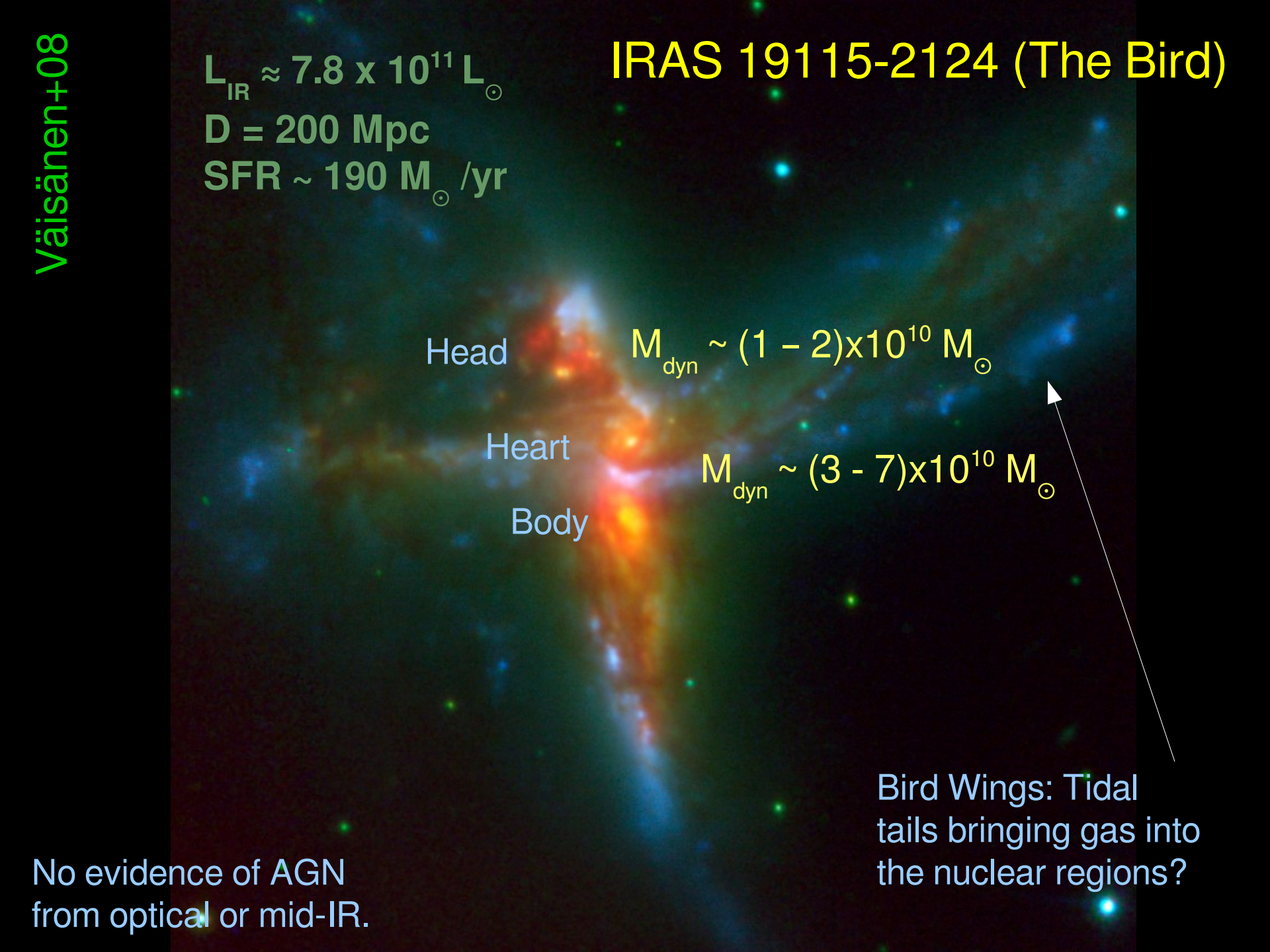


gas-rich galaxy mergers: enhancement of star formation and possibly triggering AGN activity (e.g., Sanders & Mirabel,96)

Central or off-nuclear SF? (see Barnes & Hernquist,92)

Arp 220 (e.g., Scoville+15)

The Antennae (e.g., Herrera+12)


Väisänen+08
$L_{IR} \approx 7.8 \times 10^{11} L_{\odot}$
D = 200 Mpc
SFR ~ 190 $M_{\odot}$ /yr
IRAS 19115-2124 (The Bird)
Head
$M_{dyn} \sim (1 - 2) \times 10^{10} M_{\odot}$
Heart
$M_{dyn} \sim (3 - 7) \times 10^{10} M_{\odot}$
Body
Bird Wings: Tidal tails bringing gas into the nuclear regions?
No evidence of AGN from optical or mid-IR.

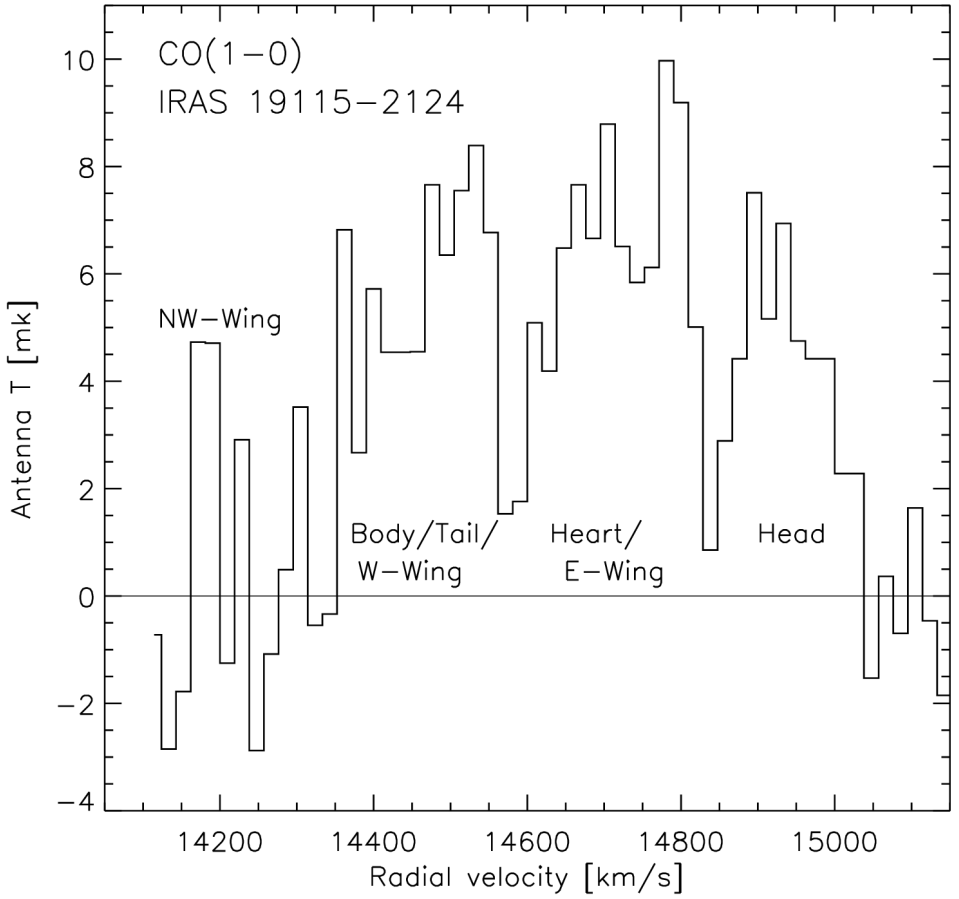
CO J=1-0 with single dish

SEST observations

Θ=44" (Mirabel+90)

$M_{H_2} \sim 3 \times 10^{10} M_{\odot}$

CO J=1-0 velocity components associated to the different NIR bright regions, based on optical spectroscopy (Väisänen+08).
So far, it seems to be simple!



An extinction-free view of the Bird
-at high resolution-

(sub-)mm

CO spectral line energy distribution (J=1-0, 3-2 & 6-5) + dust measurements (1 & 0.5 mm) with **ALMA**

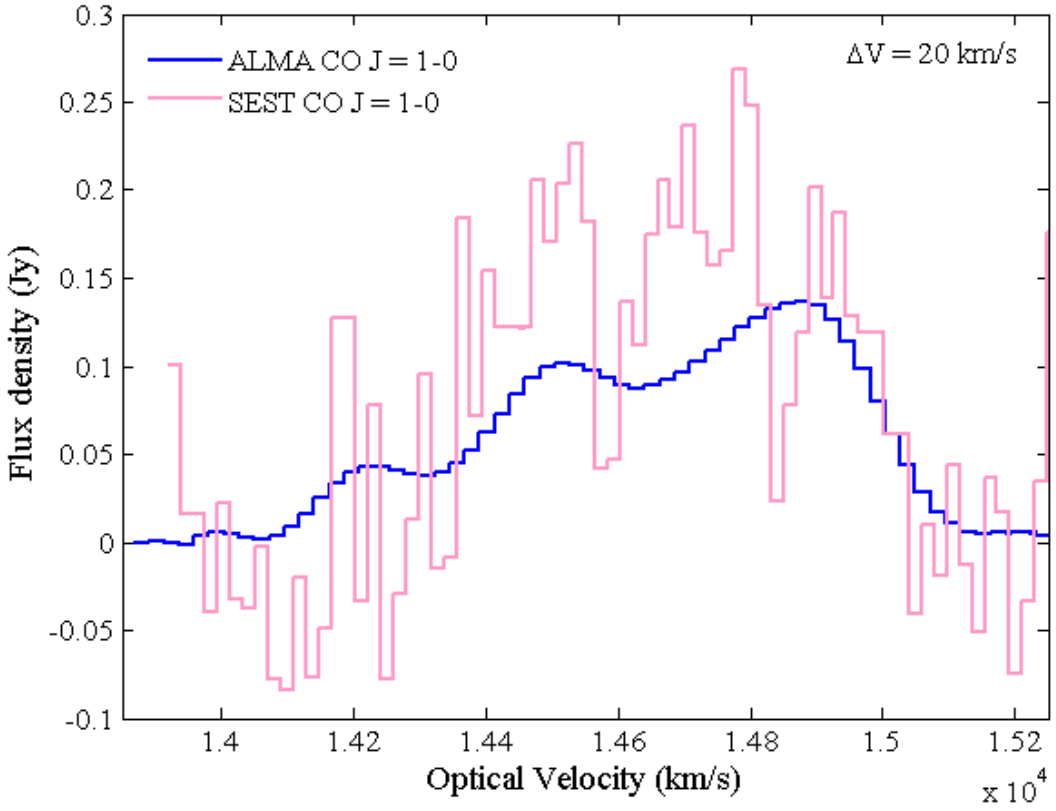
→ project 2013.1.00328

cm

Radio emission at 1.5, 3, 6 and 10 GHz + HI emission with the **VLA**

→ project 15A-253

CO J=1-0 (ALMA)



SEST

Θ=44" / Δv=20 km/s

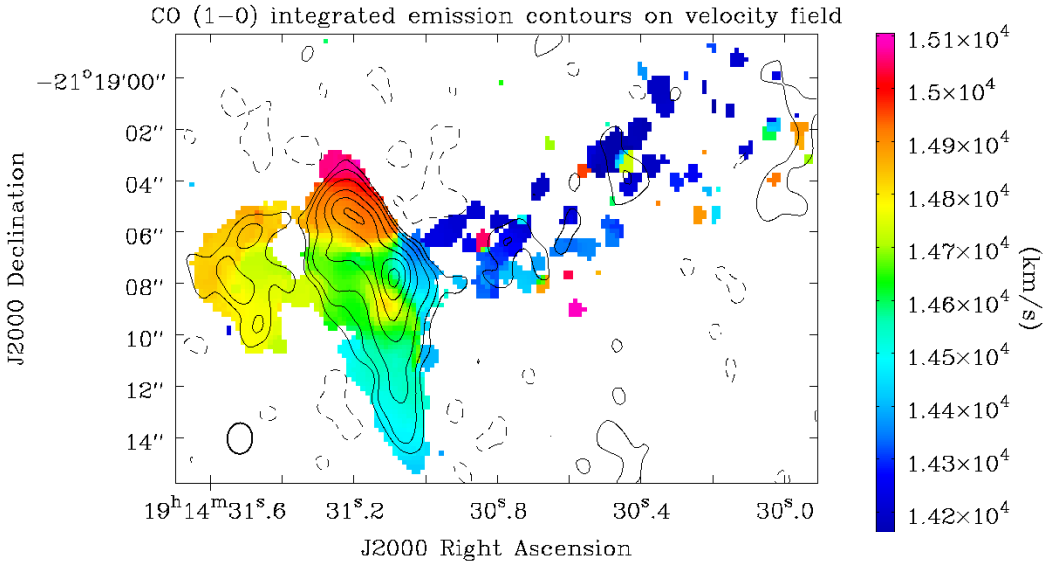
ALMA

Θ=1"x1" / Δv=10 km/s

rms = 1.3mJy/beam

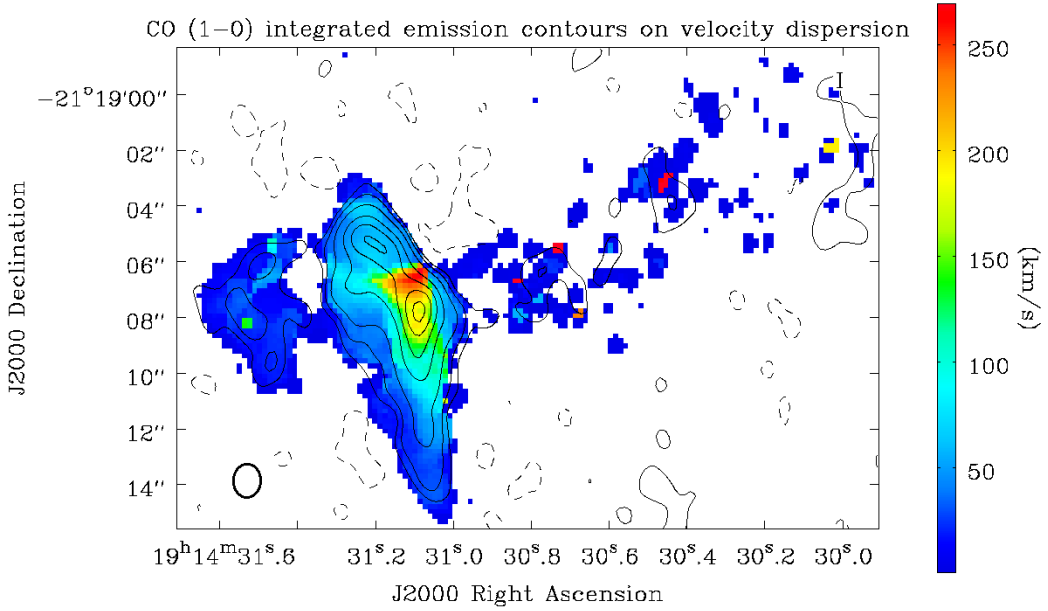
CO J=1-0 → variability?
Differences probably due to higher noise in SEST obs.

CO J=1-0 More complex than we previously thought...

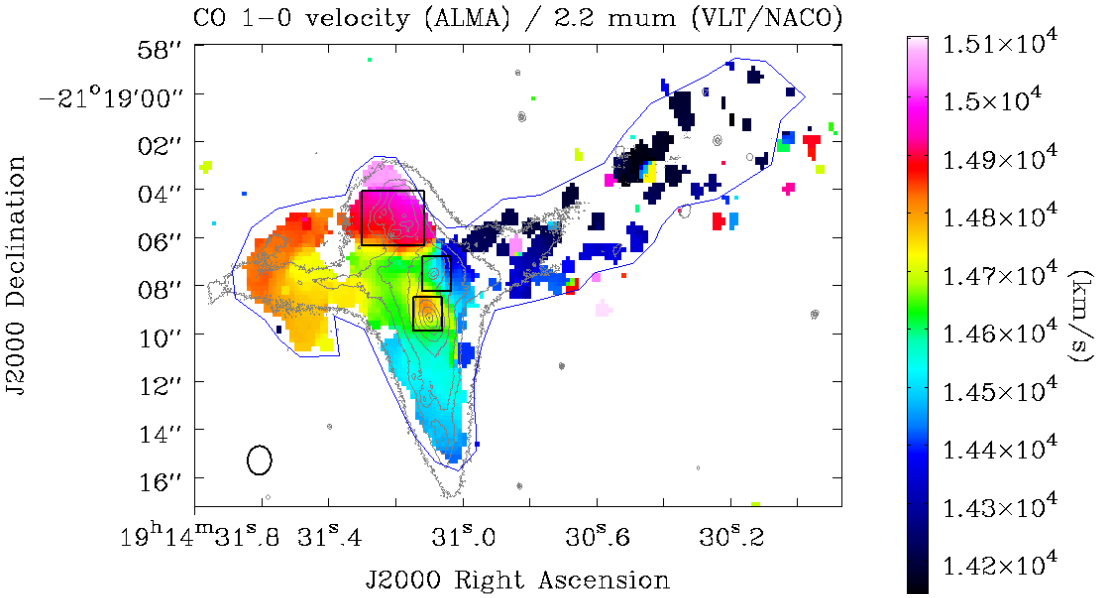


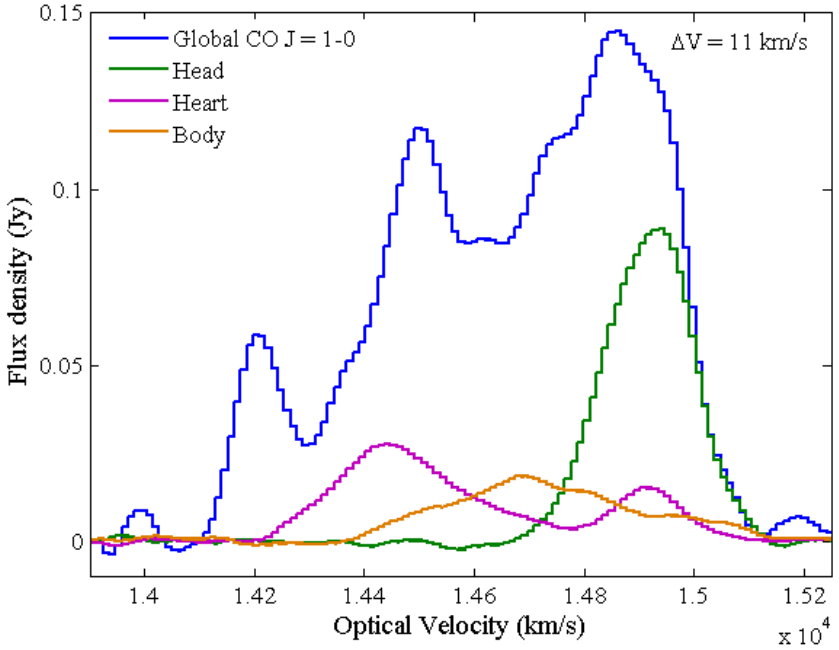
... different things going on there

High velocity dispersion – hindering further star formation in heart and body?



CO J=1-0 probing the association among velocity and spatial components





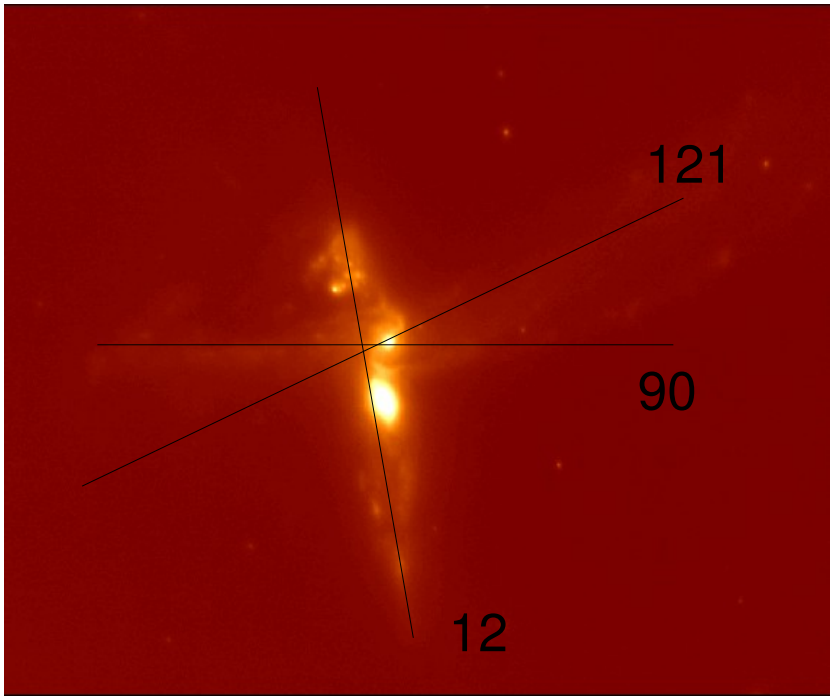
Fitting Gaussian components and assuming:

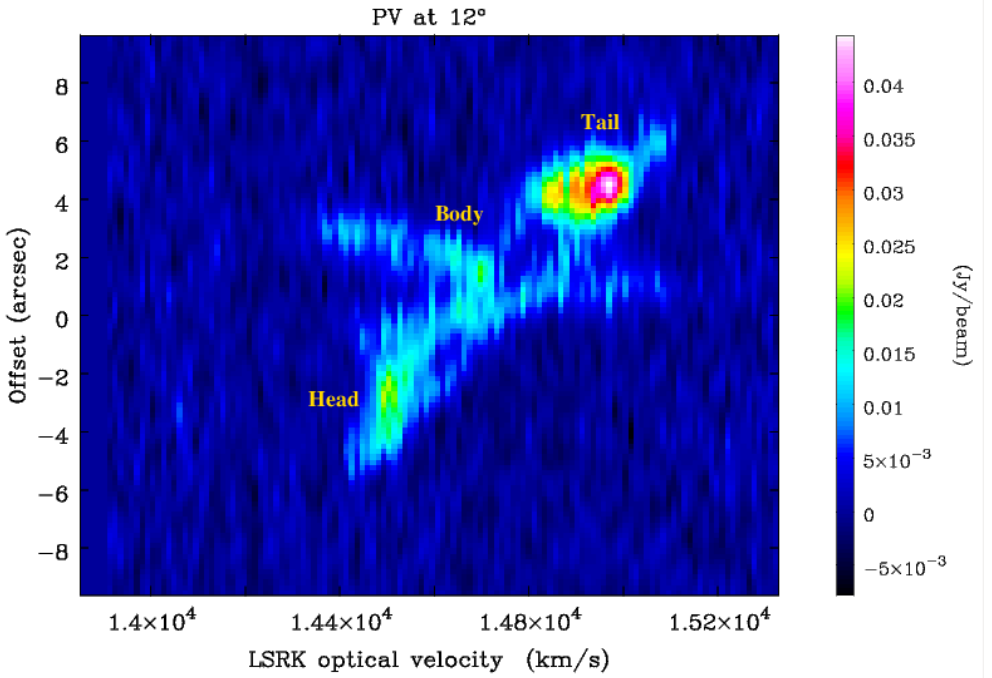
$\alpha_{CO} = 4.4\ M_\odot\ (K\ km\ s^{-1}\ pc^2)^{-1}$

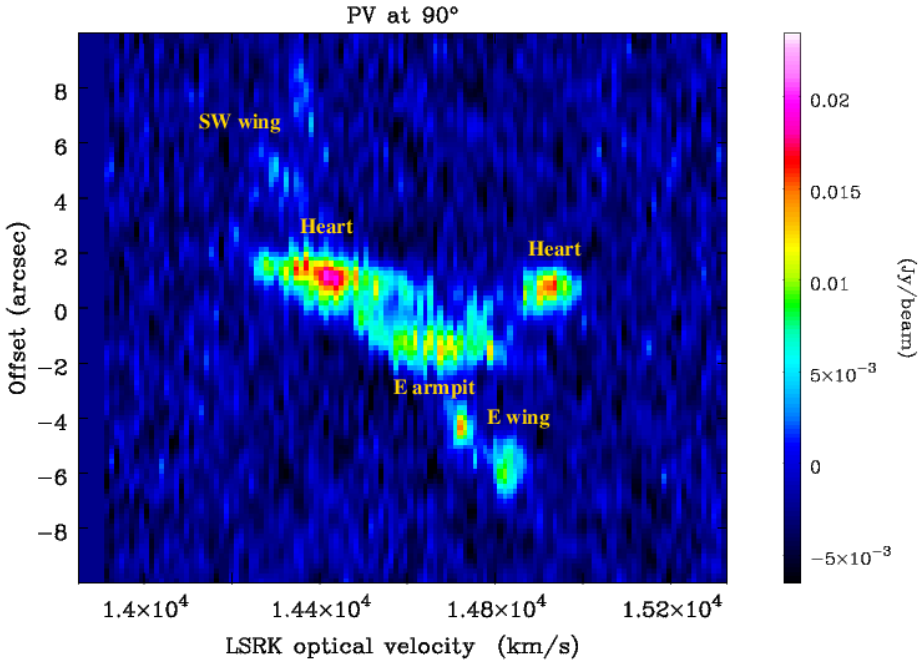
(Bolatto+13) we find:

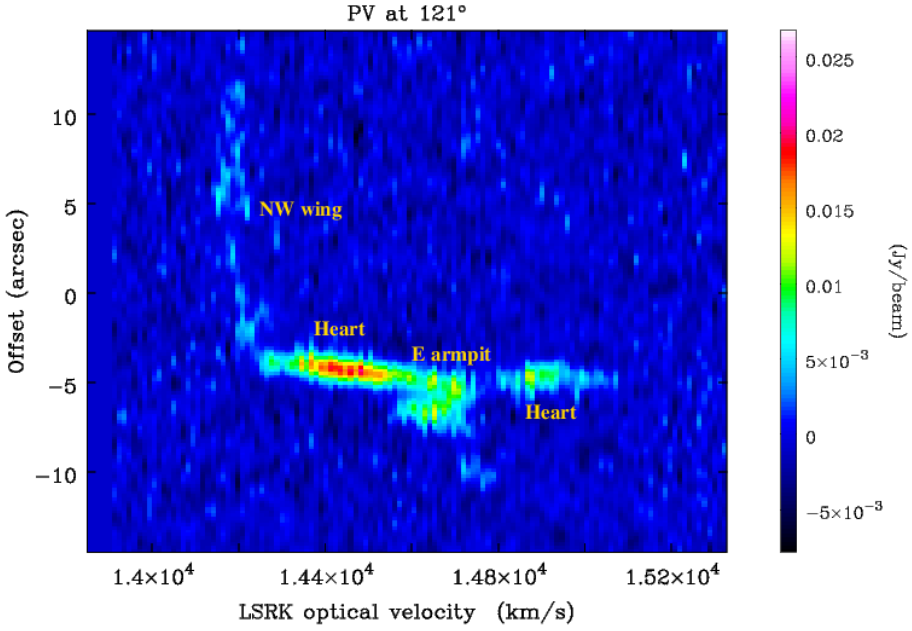
$M_{global} \sim 3.3 \times 10^{10}\ M_\odot$

20% in the head
10% in the heart
10% in the body
60% elsewhere!

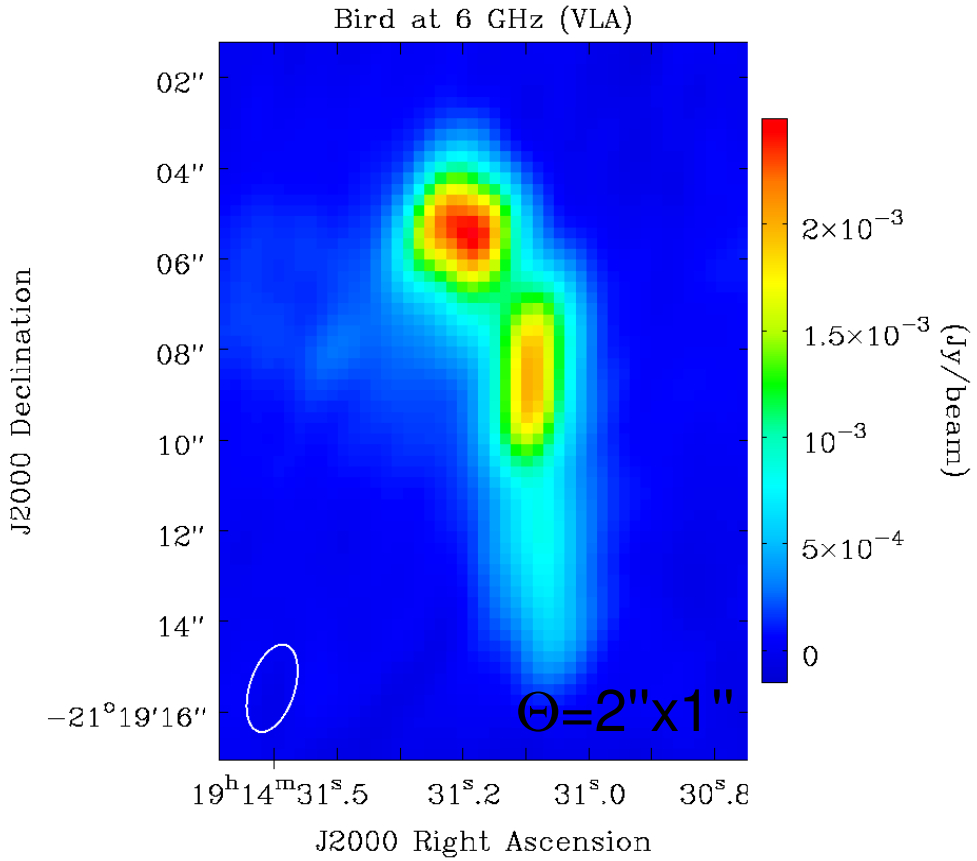

121
90
12

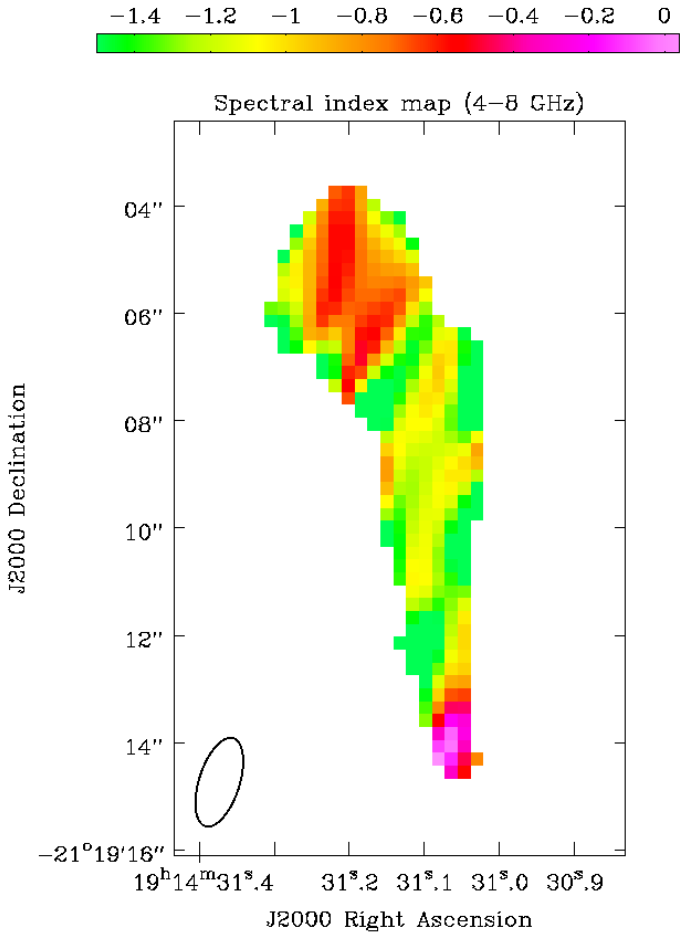

PV at 12°
Tail
Body
Head
Offset (arcsec)
8
6
4
2
0
−2
−4
−6
−8
1.4×10^4
1.44×10^4
1.48×10^4
1.52×10^4
LSRK optical velocity (km/s)
0.04
0.035
0.03
0.025
0.02
0.015
0.01
5×10^−3
0
−5×10^−3
(Jy/beam)


PV at 90°
SW wing
Heart
Heart
E armpit
E wing
Offset (arcsec)
8
6
4
2
0
−2
−4
−6
−8
1.4×10^4
1.44×10^4
1.48×10^4
1.52×10^4
LSRK optical velocity (km/s)
0.02
0.015
0.01
5×10^−3
0
−5×10^−3
(Jy/beam)


PV at 121°
NW wing
Heart
E armpit
Heart
Offset (arcsec)
10
5
0
−5
−10
1.4×10^4
1.44×10^4
1.48×10^4
1.52×10^4
LSRK optical velocity (km/s)
0.025
0.02
0.015
0.01
5×10^−3
0
−5×10^−3
(Jy/beam)

4-8 GHz radio emission (VLA)

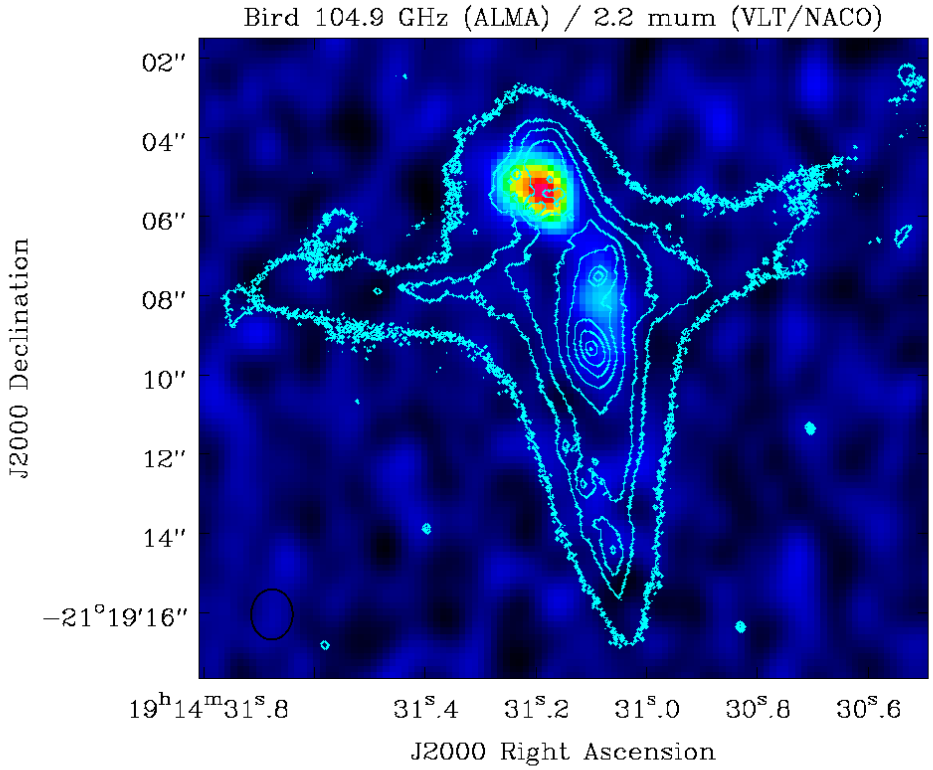


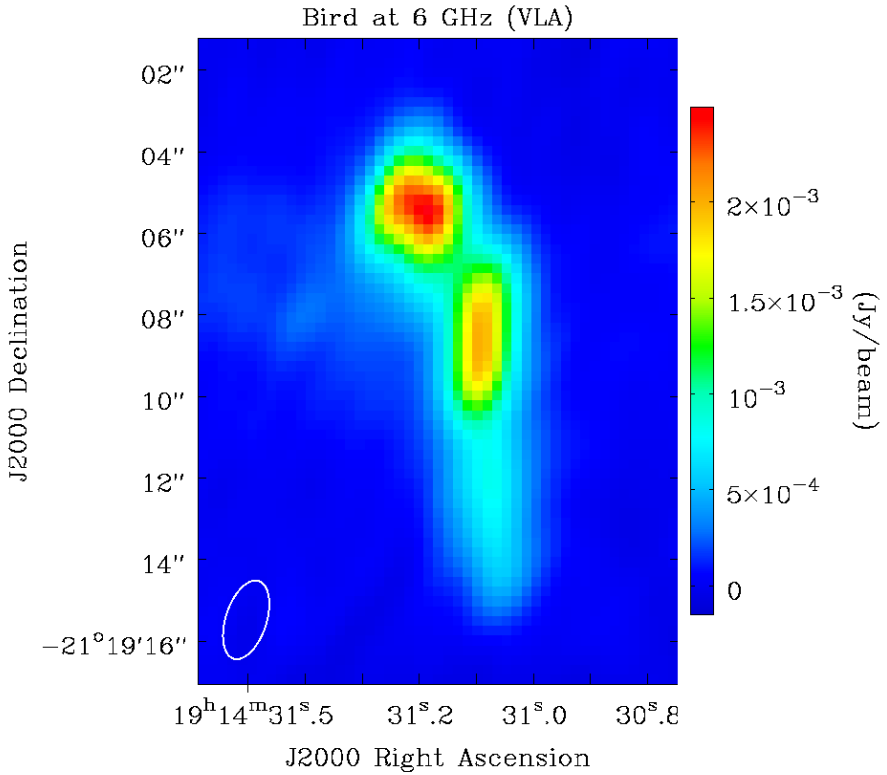


$S_\upsilon \propto \upsilon^\alpha$

~40% of the total emission is in the head

Continuum: mm vs. radio





S_{104GHz} ~ 1.5 mJy

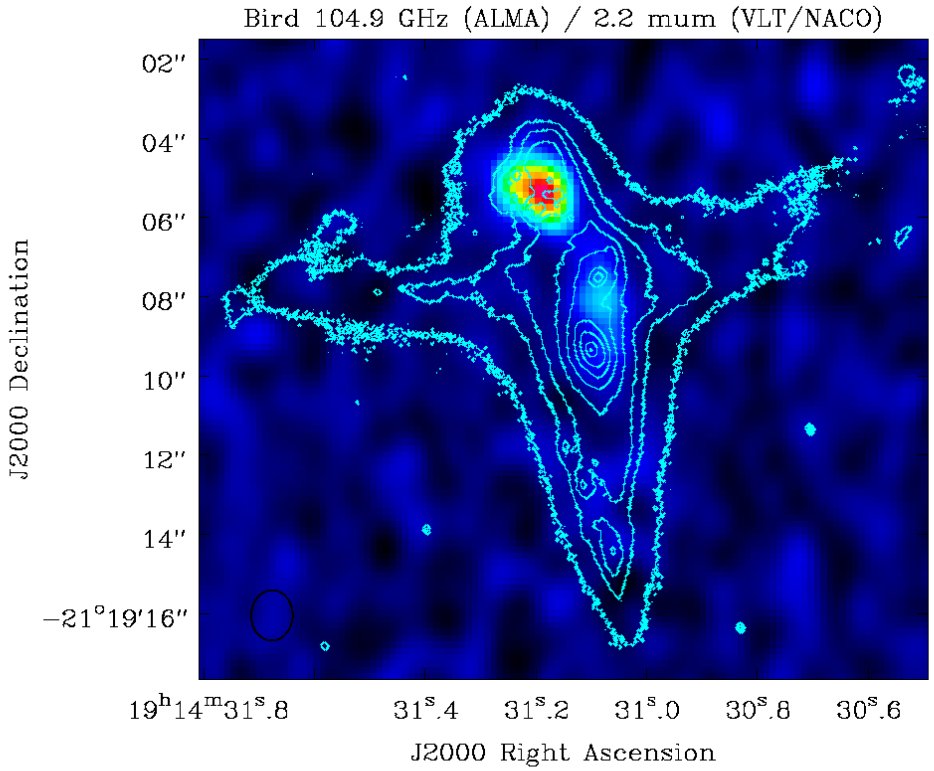
S_{6GHz} ~ 11.4 mJy

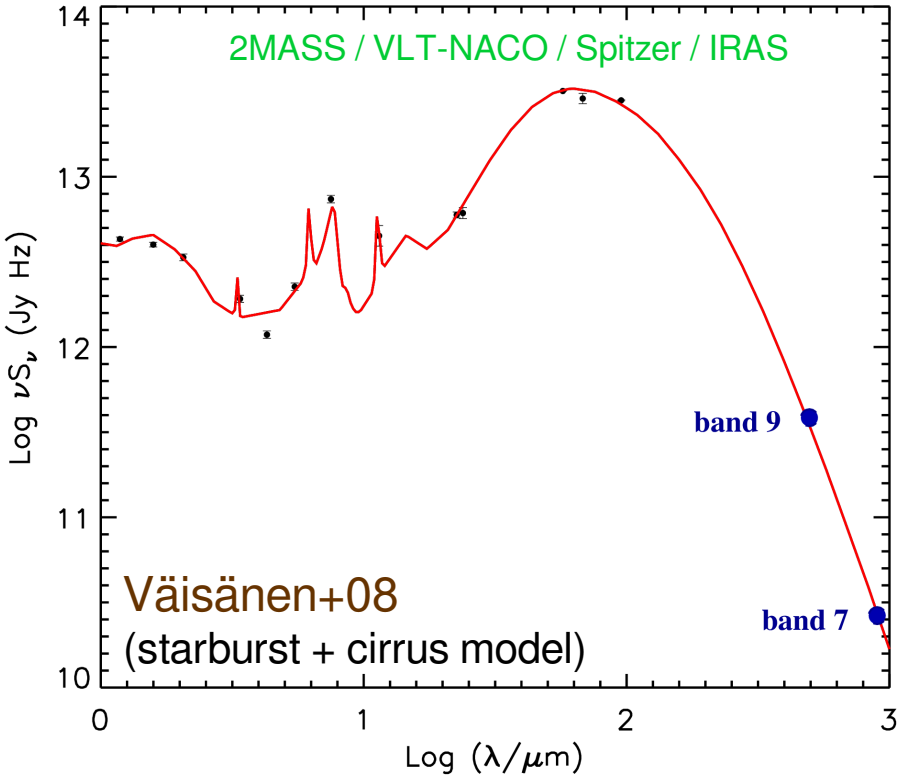
α = - 0.8 $\Rightarrow$ S_{104GHz} ~ 1.1 mJy

Dust emission or contamination?

Dust detection

Is the head driving the LIRG phenomena in the Bird?





What about the heart and the body? Continuum/dust depleted?

$S_{945\mu m}$ ~ 70 mJy

$S_{466\mu m}$ ~ 680 mJy

Summary

Molecular gas all over the Bird, but the head has the CO J=1-0 peak, as well as synchrotron emission typical of recent SF activity.

A very complex system – and a spectacular merger!

The highly extinguished body has an outflow: SF or AGN?

To be done: much more analysis on current data, complemented by future HI + further synchrotron continuum observations and ALMA bands 7 and 9

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